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16. Abstract

Implementation of the Third Generation En Route ATC System, Model A3d2, provides basic automation capability for processing flight data and surveillance functions. Substantial upgrading of this basic capability is needed to meet the demand forecast for the en route system through the 1980's. This document describes the development plan to build the features and functions necessary for upgrading the present Third Generation En Route System. Program objectives, development activities, implementation considerations, and resource estimates are set forth.

This Program Plan, FAA-ED-12-2B, supersedes Program Plan, FAA-ED-12-2A, En Route Control, dated February 1975.

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FOREWORD

This document describes the engineering and development plan for FAA
E&D Program 12, En Route Control. It provides the framework for
development of En Route air traffic control system improvements.
Program objectives, development activities, relationships with other
E&D programs and resource projection estimates are presented.

The plan is intended to provide guidance to personnel actively
involved in En Route System development activities and to provide a
tool for continuing management and control. The plan also serves as a
basis for estimating and programming the resources required to
accomplish the En Route System development effort.

This plan will be revised and updated as necessary to reflect changes
in requirements and resources and to insure compatibility with other
agency development efforts.

i

TABLE OF CONTENTS

ii

1. INTRODUCTION

1.1 Background

As a result of increasing volumes and different types of air traffic, improved equipment and techniques have been introduced into the National Airspace System since its inception. These improvements have been introduced in increments over successive time periods. When significantly improved equipment and techniques were introduced, a new generation system was considered to have begun.

The Third Generation ATC System is now implemented. One of the major components of the Third Generation ATC System is the computer-based semi-automated En Route air traffic control system. A brief description of this system is presented in Appendix A.

Substantial evolutionary improvements to the Third Generation ATC System have been recommended in order to meet the anticipated traffic demands in the 1980's and beyond.[1] Broad concepts, general design criteria and a description of a system incorporating representative evolutionary improvements are included in Report FAA-EM-78-168.[2]

An aggressive development program is needed to build the features and functions necessary for the En Route system. Efforts will be accomplished through coordination with the operating services throughout all phases of the development cycle. Inputs from the operating services during the establishment of the functional and technical requirements for the development efforts are of particular importance. Coordination of the scheduling and phasing of development products for implementation is also important.

This program plan sets forth the engineering and development plan for FAA R&D Program 12, En Route Control. This plan describes the objectives, approach, technical development efforts, implementation considerations, and the transition of management responsibilities that are required to implement evolutionary improvements in the System.

1.2 Organization of Plan

1. Section 1 includes background information.

2. Section 2 sets forth the purpose and objectives of the En Route Control Development Program.

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[1] Report of Department of Transportation Air Traffic Control Advisory Committee, December 1969.

[2] Definition, Description and Interfaces of the FAA's Developmental Programs, September 1978.

3. Section 3 describes the structure of the technical program and identifies the required development activities, as allocated to individual subprograms.

4. Section 4 describes activities in other E&D programs that have interface or design implications to the En Route Program.

5. Section 5 identifies the organization responsible for development and describes the anticipated transition of products from development to implementation. It also identifies the factors germane to implementation planning.

6. Appendix A briefly describes the Third Generation En Route ATC System, Model A3d2. This is the baseline system to which the development program described in this plan applies.

7. Appendix B presents the current schedule for the technical development projects.

8. Appendix C presents resource estimates to carry out the technical program.

2. PROGRAM PURPOSE AND OBJECTIVES

2.1 Purpose

Provide the E&D efforts to upgrade the capacity, performance and functional capabilities of the en route control system and develop the necessary interfaces with other systems to safely and effectively accommodate future air traffic requirements.

2.2 Objectives

1. Develop advanced automation functions to improve the controller's ability to control increased numbers of aircraft with a constant or increased level of safety. Planned automation improvements include an improved man-machine interface design, Electronic Tabular Display Subsystem, Conflict Alert for VFR Intruders, Conflict Resolution Advisories, En Route Minimum Safe Altitude Warning, and En Route Metering.

2. Develop the operational concepts and design changes to en route system hardware and software, including the Direct Access Radar Channel, to enable it to operate with the DABS and its Data Link.

3. Provide for off-loading of the en route CCC computer system and extending its capabilities to accommodate additional functions and the increases in air traffic. Planned improvements include a radar display recording/playback subsystem and an interface processor.

4. Develop product improvements and provide sustaining engineering in support of commissioned en route systems.

3. TECHNICAL PROGRAM

The technical program for development of advanced En Route automation capabilities is described in this section. Engineering and development activities included in the En Route Control Program are organized into program elements and subprograms that have been established to facilitate the definition, management, and accomplishment of the various projects. The type of activity included in each of the above is as follows:

Program Element 122 - En Route Experimentation and Development

1. Subprogram 122-109, Development Support

This subprogram provides for specialized development support at the National Aviation Facilities Experimental Center (NAFEC) required to sustain the variety of En Route projects at the facility. It includes ARD-140 efforts at NAFEC involved with day-to-day management of software development, testing, and documentation. It also includes support to maintain the En Route System Support Facility (SSF) at NAFEC that is used to accomplish development, experimentation, and test of advanced automation capabilities.

2. Subprogram 122-110, Program Planning and System Engineering

This subprogram includes the efforts of in-house personnel and the system engineering support contractor to perform the initial system studies and planning needed to identify and define new En Route functional and technical capabilities, interface requirements resulting from other program developments, and related dependencies. This activity provides guidance for the project-level development efforts in Program 12.

3. Subprogram 122-111, NAS Stage A Improvements

This subprogram provides for improvements in the effectiveness of the present En Route System. It includes hardware and software development activities which are intended to improve existing capabilities and features of the En Route system.

4. Subprogram 122-112, Automation Functional Development

This subprogram provides for new automation functions for En Route system applications which primarily involve software development activities. It includes the development of computer programs to provide additional automation assistance in performing air traffic planning and control functions.

5. Subprogram 122-113, Automation Equipment Development

        This subprogram provides for the development of new
automation equipment, with the related software and operational
procedures that will provide additional automation capabilites for
the En Route system.

6. Subprogram 122-114, Performance Analysis and Evaluation

        This subprogram provides for performance assessment of
automation capabilities developed for the En Route system. It
includes hardware and software measurement and analysis, simulation
and modeling, and system and controller performance evaluation to
determine the impact and benefits of introducing new automation
features.

7. Subprogram 122-115, Interface Development

        This subprogram provides for the development of hardware and
software interfaces between the En Route System and other systems.

Program Element 123, Advanced En Route Development

        This program element provides for a portion of the long-range
development activities which are intended to establish hardware and
software designs for replacement of the existing ATC automation
system including the En Route Data Processing System.

        This effort, called ATC Computer Replacement, is a separate
activity from those described in this document, and a separate
Engineering and Development Plan will be written for it. The
technical description, schedules, and funding for ATC Computer
Replacement are, therefore, not addressed in this Program Plan.

Program Element 124 - En Route Sustaining Engineering

1. Subprogram 124-111, En Route Sustaining Engineering

        This subprogram provides for developmental support in the
analyses and resolution of field system problems and design
deficiencies.

EN ROUTE SYSTEM DEVELOPMENT PROJECTS

To facilitate effective management and control of the diversity of
development efforts in the En Route Program, subprograms defined
above are further divided into projects. Development projects to be
accomplished within each subprogram are described in the remainder of
this section.

3.1 Subprogram 122-109, Development Support

This subprogram provides support resources for En Route development projects to be accomplished within other subprograms. Currently, the support is partitioned between two major projects; (1) Computer Software Development Support and (2) the System Support Facility as described below.

3.1.1 Computer Software Development Support

This project has been established to account for the ARD-140 support activities at NAFEC that manages the software support for Program 12 engineering and development projects accomplished at that location. Many of the other subprograms described in this plan will result in experimental or prototype software products that will eventually be implemented in new computer program models or as changes to the current model (A3d2). The en route software system is large and complex, and strict quality control must be used for software changes and software documentation to preserve system integrity. Direct day-to-day technical management of software development activities being accomplished by contractor personnel is needed; to insure design integrity and consistency in the software documentation, to provide timely interpretation of specification requirements, and to arrange for government furnished facility support used in software development and testing.

3.1.1.1 Activities

Activities of this project include the following:

1. Providing technical direction of contract computer programming activities for En Route development projects.

2. Providing software technical expertise in support of procurement activities, computer program designs, test designs, and evaluation.

3. Directing testing of contractor produced computer programs and insuring that software products delivered are in conformance with approved specifications.

4. Providing configuration control over simulation models, support computer programs and other software tools related to development activities.

5. Preparing estimates of computer sizing and computer use requirements related to development activities.

6. Coordinating technical support requirements to insure that resources needed for software development, testing, and evaluation are appropriately scheduled and efficiently utilized.

This activity includes involvement until the point of software transition to the operating services. The activities in this project will provide support to separate experiments conducted under the development subprograms, and to the implementation of individual changes. This project also supports the preparation of software documentation for delivery to the operating services.

3.1.2 System Support Facility

The System Support Facility (SSF) activity is intended to ensure an adequate Air Traffic Control system test bed that is continually updated in step with the latest development projects in both system hardware and software areas. A system test bed is necessary to demonstrate and provide automation concepts and procedures before making field implementation decisions. Special engineering test beds may be required when significant new hardware subsystems or concepts are under development.

An en route SSF established at NAFEC has been used to support the development and implementation of the en route system. It is currently being used by the Operating Services to support the maintenance of computer programs as well as a variety of development projects. It consists of 9020A/D computers, Computer Display Channel, Display Channel Complex, System Maintenance Monitoring Console, Direct Access Radar Channel and interfaces with terminal test beds. Test inputs are available from the Air Traffic Control Simulation Facility (ATCSF) and from live Radar and Beacon/Common Digitizer systems. A hardware interface has been established between the ATCSF and the SSF to allow simulation of Discrete Address Beacon (DABS) and Automatic Traffic Advisory Resolution Service (ATARS) functions. Interfaces between the SSF and the DABS engineering model systems that will be evaluated at NAFEC are being developed.

3.1.2.1 Activities

The efforts supported by this project are oriented toward maintaining and updating the SSF in the accomplishment of development tasks under the various En Route subprograms.

    1. Acquiring, installing, and testing any required changes to the test facilities of the SSF.

    2. Managing and maintaining the SSF.

       NAFEC has responsibility for the management of the SSF. Support costs are apportioned between the Operating Services and Development Programs on the basis of projected utilization requirements. The physical integration of the Electronic Tabular Display Subsystem (ETABS) (see subprogram 122-113) and provisions for DABS hardware interfaces (see subprogram 122-115) will be accommodated under this project.

3.2 Subprogram 122-110, Program Planning and System Engineering

3.2.1 Scope of System Engineering Activities

Subprogram 122-110 includes in-house system planning and system engineering contractor activities to identify new en route development requirements, identify and specify interface requirements resulting from other E&D programs, and to define related en route subprogram dependencies. The program planning and system engineering efforts ensure that (1) the interactions between the individual en route functional and performance improvements are considered in arriving at a viable system design, (2) the resultant design is consistent with capacity, performance, productivity, and safety goals, and (3) the development activities remain responsive to the needs and priorities of the operational services.

General objectives and activities of Subprogram 122-110 are as follows:

1. Formulate the design concept for near term enhancements for en route automation which considers how future improvements will be integrated with the current base system, how they will interact with each other, and which relates each improvement to specific system objectives. Activities include data collection, data analyses, and simulation modeling as appropriate.

2. Prepare preliminary operational concepts, functional specifications and design requirements for the individual development features which are in consonance with the overall en route system design and which satisfy approved objectives. These preliminary concepts and design requirements will provide the initial guidelines for the development activities performed under the other en route subprograms.

3. Assess all E&D programs and identify new en route interface requirements, identify en route subprogram interdependencies, and establish development plans.

4. Assess en route computer requirements with consideration to future processing, display, storage, and response time; provide recommendations for computer capacity needed for recovery and augmentation developments to be performed under other subprograms.

5. Provide support to the preparation and update of en route development and design definition documentation such as the En Route System Description, Operational Computer Program Description, and En Route Program Development Plan.

6. Prepare subprogram control documentation (at a level below this Program Development Plan) and develop program planning and program management techniques required to carry out the en route E&D

activities defined herein. This activity includes preparation of design evaluation test plans and documentation of test results. Specific studies and activities that are currently underway or planned under this subprogram relate to the following areas and are described in the remainder of this section:

  a. Applications of ATC Data Link
  b. Traffic Organization and Management
  c. Requirements for Interfaces with other Programs
  d. Sector Position Development
  e. Preparation and Updating of the En Route Engineering and Development Program Plan

3.2.1.1 Applications of ATC Data Link

Significant capabilites for increasing productivity, safety and capacity of the En Route system appear to be achievable by applications of ATC data link.[3] Automatic generation and transmission of various types of message for control and information transfers between ground facilities and aircraft are necessary to realize the projected productivity, safety and capacity gains. Processing requirements for the variety of data link applications which appear feasible vary widely. Some applications such as relaying beacon codes, altimeter settings, and assigned altitudes may be realized by simply extracting existing information from automated data bases, formatting it for transmission and applying appropriate communications protocols to insure error-free transmissions and acknowledgements. Other applications involving critical control functions will require creation of automatic problem detection and resolution decision logic to determine appropriate information for data link transfers. Thus, some data link applications are inextricably related to and dependent upon other automation functional developments such as: Conflict Detection and Resolution, Minimum Safe Altitude Detection and Resolution, and En Route Metering. Furthermore, appropriate man/machine interfaces must be developed to insure that integrity of the control process is not compromised.

A system study will be conducted to identify en route data link applications, to define message characteristics, technical requirements, and appropriate time phasing for the various functional capabilities to be derived. This activity will aid in defining areas where design work and validation testing are needed. To assure acceptance of the results of system testing, it will be necessary to develop quantitative techniques for determining the effect of control message automation on controller workload and productivity. The detailed development, testing, and design validation will be accomplished under Subprogram 122-112 (reference subsection 3.4.6 Control Message Automation).

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[3] Controller Productivity in the Upgraded Third Generation Air Traffic Control System, MTR-7319, August 1976

3.2.1.2 Traffic Organization and Management

A number of functions have been proposed to achieve the general objective of improving the efficiency of traffic movements. The goal is to improve controller productivity while maintaining or improving existing safety levels. A system definition activity is needed to consider the total traffic organization and management capability. The critical aspect of this work effort is the definition of the relationship which each proposed function has to the other system functions.

This system definition activity will establish the operational needs, data input and output, and data base and processing requirements for each traffic organization and management function. This activity is expected to resolve potential overlap between traffic management functions and will provide the guidelines for development of the required system functions. As a minimum, the traffic organization and management aspects of the following functions will be considered:

    Conflict Resolution Advisory
    En Route Metering
    En Route Minimum Safe Altitude Warning

A broad analysis of all functions for traffic organization and management is needed so as to define the role each function is expected to fulfill when considering each major phase of flight. The functional interface requirements with other programs, e.g., Terminal/Tower Control, will also be identified and defined. By defining the stipulated criteria for each function through analysis under this subprogram, technical guidance and constraints will be established which can then be used to define the technical details, algorithms, etc., of each function for project development, testing, and design verification under other subprograms.

3.2.1.3 Requirements for Interfaces with other Programs

The en route system is the focal point for the collection and dissemination of all flight, surveillance, aeronautical and meteorological data to the en route controllers. As such, many of the other E&D development programs will require interfaces with the en route system and will require software and, in some instances, hardware interface modifications or augmentation. As each new en route interface is identified, the interface requirements and the impact upon the en route automation subsystem will be analyzed and a preliminary interface design defined. In certain areas, analyses will be conducted to identify new requirements which must be developed under other programs, such as improved techniques for disseminating weather data. Specific products will include preliminary interface design documentation, requirements for en route software changes, and interface development and design validation plans. Interface development, test, and design validation activities will be performed under Subprogram 122-115, Interface Developments (reference subsection 3.7).

3.2.1.4 Sector Position Development

Substantial savings in control sector staffing appear to be achievable by incorporating improved display presentation and data entry capabilities at the en route sector positions.[4] These capabilities are expected to result in increased controller productivity and greater capacity for the control sector with equal or improved safety.

Sector position development activities focus at the man/machine interface. Thus, they interrelate the human element, procedures, hardware, and software aspects of the system. Activities conducted under this effort include the formulation of sector position functional requirements, and general concepts and design approaches for hardware and software. This effort will also perform basic investigations concerning the use of improved display presentations and data entry devices at the Data (D) and Radar (R) sector positions of operation. Initial activities are primarily associated with current system functions and operations, however, these activities will also consider other development work planned or in progress that could affect sector position system design e.g., control message automation and en route metering.

Detailed development and design validation activities will be conducted under Subprogram 122-113, Automation Equipment Development (reference subsections 3.5.1 and 3.5.2). Test and evaluation support will be provided for under Subprogram 122-114 (reference Subsections 3.6.3 and 3.6.4).

3.2.1.5 Preparation and Updating of the En Route Engineering and Development Program Plan

Periodic revision of the Engineering and Development Program Plan for En Route Control will be accomplished. Reviews of work activities, goals, and objectives will be conducted and preparation of revisions or editions will be accomplished as necessary to keep the plan current and improve its utility as a planning document.

3.2.2 Products

The products from the activities of this subprogram (122-110) includes analysis reports, preliminary functional specifications, interface documentation, development plans, test plans, and design validation plans. These products are completed prior to initiating the development, test, and design validation activities accomplished under projects of the other subprograms. The preparation of the

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[4]. Cost Analysis of Electronic Tabular Display Subsystem, FAA-AVP-77-31, September 1977

final documentation for implementation, operation, and maintenance of the system is completed under this subprogram with support from Subprogram 122-109 prior to hand-off to the operating services for implementation.

3.3   Subprogram 122-111, NAS Stage A Improvements

This subprogram covers engineering and development efforts to improve the effectiveness of the present En Route System.   It includes hardware and software development activities which are intended to improve existing capabilities and features of the En Route System. Products of development projects in this category are not intended to provide new functional capabilities.   However, improvements in system peformance, capacity or safety may result from their application. The development project included under this subprogram is:

   1.   Surveillance System Improvements

3.3.1   Surveillance System Improvements

A new approach to the processing of primary radar returns is represented by the Moving Target Detector (MTD) radar processing system.   This equipment measures the range rate of primary targets with an accuracy which is expected to be of the order of three knots.   Calculations have been made which indicate that with MTD equipment it should be possible to detect an aircraft in turn within one scan period (usually 10 seconds).   This information should be useful in early detection of aircraft turns and should improve the performance of the Conflict Alert (CA) and the Mode C Intruder (MCI) functions described in Subsection 3.4.1 and the En Route Minimum Safe Altitude Warning System (E-MSAW) described in Subsection 3.4.3.

3.3.1.1   Program of Development Activities

Initial activities under this project focus on confirmation of range rate accuracy using various targets of opportunity.   Modeling will then be used to determine what tracking improvements may be expected and what resultant system improvements in the CA, MCI, and E-MSAW functions may be expected if range rate reporting is included in the en route system.

If the initial activities conducted under this project appear promising, then the en route tracking program will be modified to use range rate data.   Test tapes merging ATCRBS and MTD radar data will be prepared and used as input to the modified tracker.   Tests will be conducted to validate the modeling results and obtain computer resource impact.

3.3.1.2   Development Products

Development products will be technical reports describing activities and the results of modeling and testing.

If results are promising, a Technical Data Package will be prepared from which the operating services can procure the software and hardware required to include range rate and range rate processing in the en route system.

3.4 Subprogram 122-112, Automation Functional Development

This subprogram covers the development of new automation functions for En Route system applications. It includes the development of computer programs to provide additional automation assistance in performing air traffic planning and control functions. Following development and experimentation activities, each new functional capability will become a candidate for incremental application to the en route system. In some cases, further experimentation and testing of logical combinations of functions may be necessary. The development projects included under this subprogram are:

1. Conflict Alert Enhancements
2. Conflict Resolution Advisory
3. En Route Minimum Safe Altitude Warning
4. En Route Metering
5. Control Message Automation

3.4.1 Conflict Alert Enhancements

The Conflict Alert function aids the radar controller in predicting where and when violation of radar minimum separation standards are about to occur. Using information presently available in the 9020 computer from the automatic tracking function and the flight plan data base, the Conflict Alert function provides the radar controller with an alert on his plan view display of the impending situation of separation being less than minimum. The alert is generated a short time before the separation minimum might actually be violated.

The function was originally developed for application to all IFR versus IFR tracked aircraft in the High Altitude Positive Control Airspace (PCA). After initial field implementation, the altitude was lowered in steps to extend the alerting capability for IFR tracked aircraft operating at the lower altitudes as well. The Conflict Alert function is presently operating at all 20 ARTCCs.

3.4.1.1 Program of Development Activities

An experimental computer program will be developed for automatically establishing tracks on the present untracked Beacon Mode C returns and providing a capability for those tracks to be processed by the current Conflict Alert function.

Testing of the experimental computer program will be conducted in the NAFEC System Support Facility. This effort will establish a design that could eventually be implemented in the current NAS En Route system. Thus, the Conflict Alert function would be extended to VFR/Mode C equipped aircraft potentially conflicting with IFR aircraft.

3.4.1.2 Development Products

Computer Program Functional Specifications for the extension of the Conflict Alert function within the current NAS En Route system will be prepared. Data reduction and analysis programs will be prepared to assist in assessing the extended capability. Test plans and analysis reports of test results will also be prepared.

3.4.2 Conflict Resolution Advisory

The conflict resolution advisory function will aid the controller in resolving potential conflicts when the conflict alert function indicates loss of radar separation minima is about to occur. Using information from conflict alert, flight plan and tracking data, conflict resolution advisory will present suggested resolutions to the controller. Resolution advisories are likely to be in the form of heading or altitude changes. The final decisions for corrective actions will be determined by the controller, using the resolution advisories generated by the computer program.

3.4.2.1 Program of Development Activities

A computer program will be developed to provide computer-generated conflict resolution advisories to the controller on a timely basis. The computer program will test possible resolution strategies and generate outputs to the controller's display with suggested resolutions. After the computer program has been developed, parameter interaction, time-sensitivity, and other analyses for man-machine interfaces will be conducted. The development and testing of the conflict resolution capabilities are expected to be accomplished in the NAFEC System Support Facility. It is anticipated that the eventual result of development and testing activities will be a conflict resolution advisory function suitable for inclusion in the en route system.

3.4.2.2 Development Products

The development will result in preliminary computer program specifications for the en route system. Data reduction and analysis programs will be prepared to assist in assessing the resolution functions. Test plans and analysis reports of test results will also be prepared. Following testing, final computer program design specifications will be completed. If required, a technical data package will be provided to the operating services for incorporating the conflict resolution advisory function into the operational system.

3.4.3 En Route Minimum Safe Altitude Warning (E-MSAW)

The E-MSAW function will aid the radar controller in predicting where and when a tracked aircraft will be below a minimum safe altitude. Using information in the 9020 computer from the automatic tracking function, flight plan data base and adapted minimum safe altitude

areas, the E-MSAW function will provide a visual alert to the radar controller's plan view display when the projected path of a tracked aircraft violates a minimum safe altitude area. The alert will be generated a short time before the minimum safe altitude might actually be violated.

3.4.3.1 Program of Development Activities

The development program will be accomplished in two phases. Phase one will provide the E-MSAW function for tracked aircraft in the en route overflight and transitioning environment, while Phase two is intended to provide the E-MSAW function for tracked aircraft in the arrival/departure environment.

For Phase one an experimental computer program will be developed using a sample set of E-MSAW areas and the Model A3d2.4 software as a base. This effort will establish a prototype software design for NAFEC testing in the System Support Facility.

Using the prototype E-MSAW software as a base, an initial implementation package will be prepared and patched to the release of Model 3d2.8 for key field site testing. Upon successful key site testing, the E-MSAW function will be incorporated into Model 3d2.9 for national implementation.

For Phase two, additional analysis and design will be conducted to determine if extension of the E-MSAW function in the arrival/departure environment is feasible. If feasible, design specifications for this addition to the E-MSAW function will be prepared and the required modification to the existing software will be made for subsequent testing at NAFEC.

3.4.3.2 Development Products

Software and accompanying documentation packages will be prepared for implementation of E-MSAW within the NAS En Route system. A data reduction and analysis program will be prepared to assist in assessing the functional capability. Test plans and analysis reports of test results will also be prepared.

3.4.4 En Route Metering

The primary objective of en route metering is to organize the traffic at higher altitudes in the en route airspace such that congestion and delays in the lower terminal airspace are kept to a minimum. By transferring the delay absorption from low to high altitude, the exposure of high performance aircraft to low altitude aircraft is decreased, the noise to people on the ground is reduced, and the fuel consumption to absorb delays is reduced. Thus, the en route metering function is a potentially significant capability in that it simultaneously addresses several important issues of air traffic control.

Due to airspace constraints, limited capability exists for holding aircraft in a terminal control area when airport acceptance rates are exceeded. When the rate of arriving aircraft exceeds the airport acceptance rate, manual en route metering provisions are normally instituted. Adverse weather, the status of ground facilities, varying aircraft performance characteristics, and fluctuations in air traffic loads are typical of the factors that bring this metering process into operation. The en route metering function will be designed to be compatible with an initial automated capability being developed by Air Traffic Service to generate aircraft landing sequence and slot times over feeder fixes. The en route metering function will augment that capability by generating controller advisories to absorb necessary delays in a fuel-conservative manner. In a later version, the design will also accommodate a digital interface with the terminal facility.

3.4.4.1 Program of Development Activities

Initial functional specifications for the en route metering function will be prepared and a computer program will then be developed to incorporate the function into the system. This program will determine the amount of en route delay to be absorbed, and will compute a recommended method for absorbing the delay in a fuel-conservative manner. The methods will include speed reduction, vectoring, profile descents, and holding. Metering advisories and associated descent and hold lists will be displayed at the appropriate upstream and arrival sectors. Displays at the metering position will include a chronological scheduled landing sequence. After this computer program has been developed; parameter interaction, time-sensitivity, and other analyses for man-machine interfaces will be conducted. The development and testing of the en route metering capabilities are expected to be accomplished at the NAFEC System Support Facility. It is anticipated that the result of these development and testing activities will be an en route metering function suitable for inclusion in the system.

3.4.4.2 Development Products

Initial functional specifications for the en route metering function will be prepared and preliminary computer program specifications for the A3d2 system will be developed. Data reduction and analysis programs will be produced to assist in assessing the en route metering function. Test plans and analysis reports of the results will also be prepared. Following testing, final computer program design specifications will be completed. A technical data package will then be provided to the operating services for incorporating en route metering into the operational system.

3.4.5 Control Message Automation

The Discrete Address Beacon System (DABS) will provide a two-way data link between airborne and ground systems. Control Message Automation

(CMA) is a project with the goal of providing, within the En Route ATC Automation System, the capability to automatically select, process, route, and format several classes of messages for two-way communications with aircraft via data link. These messages include control messages (clearances and restrictions) and advisory information messages (weather advisories, etc.). It is expected that automating the selection and delivery of control messages will increase controller performance by allowing them to control more aircraft or a larger airspace (or both), while maintaining or improving upon existing levels of aircraft safety.

3.4.5.1 Program of Development Activities

The DABS Data Link Application Development Program[5] has identified several specific data link services as candidates that could be implemented in the field during the same time period as the DABS sensors. One of the data link service candidates that has been identified, altitude assignment confirmation, is associated with en route control. During en route phases of flight, controllers presently issue altitude changes to pilots using voice communications. They also enter this information in the en route computer system via keyboard actions to maintain a current data base. The capability of providing for an uplink delivery of assigned altitude messages when they are entered in the en route computer system data base will be developed, tested, and evaluated. This confirmation via data link should eliminate pilot misunderstandings of altitude assignments resulting from inherent problems associated with a voice system. The test and evaluation effort will be conducted at NAFEC using the en route SSF and the DABS Engineering Models.

As they are developed and tested, en route control functions which are performed by automation will be evaluated to assess the desirability of utilizing CMA to further automate the functions. Those functions showing promise for inclusion in CMA will be developed further to provide for automated delivery of control messages via data link.

Where appropriate, hardware developments within the scope of the En Route Control Program will be evaluated to determine their benefits with respect to CMA. For example, an Electronic Tabular Display Subsystem (see Section 3.5.1) with its flexible data output and touch entry capabilities would appear to greatly simplify controller composition of messages for delivery to aircraft via data link.

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5. Data Link Experiments Program Plan, FAA-ED-06-2.

3.4.5.2 Development Products

Expected products of this effort are developmental ATC software and documentation evaluation reports of technical and operational suitability, and recommendations for the controller-computer interface.

3.5 Subprogram 122-113, Automation Equipment Development

This subprogram covers the development of new automation equipment, along with the related software and operational procedures that will provide additional automation capabilities for the en route system. The development projects included under this subprogram are:

1. Electronic Tabular Display Subsystem
2. Radar Position Input and Display
3. Radar Display Recording/Playback System
4. Interface Processor Development

3.5.1 Electronic Tabular Display Subsystem (ETABS)

This project provides for the development, test, and evaluation of an engineering model Electronic Tabular Display Subsystem (ETABS) to replace the current paper flight progress strips, Flight Strip Printers and Computer Update Equipment. A major objective of this subsystem is to reduce the Data ("D") controller workload and provide more effective air traffic control.

Paper flight strips are currently used as the basic method of posting flight data information at en route control sectors. Electro-Mechanical Flight Strip Printer units print initial and updated flight strips that are distributed to the proper sectors under computer control. The flight strips must be torn from the printer, separated, and inserted into flight strip holders. Controllers are then responsible for arranging the strips according to location (fix postings), sequencing them according to time and altitude, and removing them when no longer needed. Controllers are also required to make dual entries to update the system and sector data bases. Controller actions resulting in modifications to flight data require controllers to input updated information to the Central Computer Complex (CCC) via sector entry devices and also hand annotate flight progress strips. These modification actions also cause update messages to be routed to other control sectors requiring controllers at these sectors to manually update their flight strips. Most of these manual activities associated with flight strip processing will be eliminated with ETABS.

Analyses have indicated that data entry to the CCC via the existing sector alphanumeric keyboards and quick action keys is time consuming. Use of these devices and input formats causes the message entry workload to be a large percentage of total sector workload. The entry techniques and devices of ETABS will be designed to replace

the existing Computer Update Equipment and reduce the "D" controller's message entry workload. The ETABS message entry technique will emphasize the use of touch entry devices (activated by touching the display with a finger) and software controlled display selection lists (menus) to guide the controller.

The ETABS design will also provide for real-time automatic updating and presentation of mode C altitude data and Conflict Alert indications at the "D" controllers positions of operation. These features are currently provided only at the radar controller positions of operation on the Plan View Displays. In addition, ETABS will provide meterological and other operational support data on a common display.

The improvements from ETABS are expected to result in manpower savings and the "D" controller being able to provide more assistance in resolving traffic control problems.

3.5.1.1 Program of Development Activities

An Engineering Requirement for ETABS, prepared under Subprogram 122-110, will be used to procure an engineering model for test and evaluation at NAFEC.

This procurement will permit six test sectors at NAFEC to be configured with ETABS. Extensive system testing will be performed with the engineering model to evaluate and refine the design and provide data for an updated cost analysis study.

ETABS system testing at NAFEC is expected to demonstrate the adequacy of the experimental design features of ETABS when applied to typical en route radar as well as non-radar control sectors. Information display content and formats, input message formats, touch entry device menu data content and branching logic, and sector related data manipulation controls will be tested. Emphasis will be placed on developing and assessing the adequacy of design features to accommodate possible failure conditions.

In addition, display design features associated with unique sectors, such as oceanic sectors and special military operations' sectors will be evaluated.

Further experimental design work will consider data display requirements and controller interfaces for new ATC functions being developed, interfaces with the DARC system, the aviation weather system, and NAS to NAS interfacility communication circuits. If required, additional effort will be expended to investigate the feasibility and benefits of ETABS performing certain flight data processing functions currently performed in the 9020 system.

3.5.1.2 Development Products

The initial development product for ETABS will be a Technical Data
Package with required reports, analyses and other appropriate
documentation to support field implementation decision activities and
the preparation of production system specifications.

3.5.2 Radar Position Input and Display (RAPID)

The purpose of the Radar Position Input and Display (RAPID) project
is to provide for the development, test, and evaluation of an
improved man/machine interface capability for the Radar ("R")
controller. RAPID is intended to provide the capability for
simplifying message entry by the "R" controller, displaying the data
ouputs of new automation functions, and improving the Plan View
Display (PVD) presentation function.

The current "R" controller equipment configuration includes a PVD, a
Computer Readout Display, an alphanumeric keyboard, a trackball, a
quick action/category control panel, a system status control panel, a
display filter control panel, a field select control panel, and
communications equipment.

Studies of sector input and output activity at the "R" controller
position indicate that (1) system input requirements constitute a
large percentage of the sector workload and (2) the methods and
devices used for data entry employing quick action keys, a keyboard,
and a trackball are time consuming and error prone. Experimentation
associated with the development of an Engineering Requirement for
ETABS (Section 3.5.1) at the Data ("D") controller position
demonstrated that the concept of touch entry is an improvement over
the present method of message composition. The concept of touch
entry will be the basis for simplifying message entry at the "R"
controller position. Message entry provided for the "R" controller
will be designed to be compatible to that of ETABS. It is expected
that most of the keyboard and control panel functions now provided by
various buttons and switches will also be accomplished by data entry
through a touch input device.

New automation functions under development such as en route metering,
conflict resolution advisory, and data link applications (Control
Message Automation) will add to the amount of information currently
displayed at the "R" position. RAPID will provide additional display
capacity for the data outputs of new automation functions such as
these in order not to increase display clutter on the PVD. The
provision of additional alphanumeric display space will also provide
for offloading some of the information currently on the PVD to reduce
clutter. The improvements from RAPID are expeced to result in
increased control sector productivity with equal or improved safety.

3.5.2.1 Program of Development Activities

An Engineering Requirement for RAPID will be prepared under
Subprogram 122-110 and used to procure an engineering model for test
and evaluation at NAFEC. Initial testing of the RAPID system at
NAFEC will be directed towards evaluating (1) the adequacy of the
hardware and software design features of RAPID for simplifying
current system input requirements at the "R" controller position (2)
the compatibility of message entry provided by ETABS for the "D"
controller, (3) the adequacy of the RAPID touch input design for
accomplishing many of control panel functions now provided by various
buttons and switches and (4) the adequacy of the RAPID design
features to accommodate possible failure conditions.

Further test and evaluation activities will then be directed towards
the man/machine interfaces for the new automation functions being
developed and towards improving the PVD presentation function. The
developement efforts conducted under the RAPID project must be
consistent with other sector position development activities such as
ETABS and color PVD's.

3.5.2.2 Development Products

The initial development products for RAPID will be reports of concept
studies and analyses, an Engineering Requirement and other
appropriate documentation to procure and engineering model of RAPID,
and documentation of the engineering model test and evaluation.

3.5.3 Radar Display Recording/Playback System

The objective of this project is to develop a capability to
accurately and reliably record, store, and playback all the
information presented on an air traffic control Plan View Display
(PVD).

At the present time, much of the data contained in the automated
system are being recorded via the System Analysis Recording (SAR)
program. Although the statistical data collected by the SAR program
are extensive, these recordings cannot be played back through a radar
display to give an accurate and complete duplication of what had
previously been displayed to a controller.

As the current en route automation system has evolved, the operating
services have indicated that it would be useful to have recording of
data in the display subsystem with a selective "playback" capability
as a means of establishing what data were being presented to
controller personnel during some particular ATC-related situation.
The ability to recreate such situations may be utilized for situation
analysis, for operational analysis, and for determination of system
performance.

A successful technique for recording and playback of PVD data was developed by the FAA and incorporated into a breadboard demonstration model at NAFEC. The breadboard model was successfully demonstrated and as a result, SRDS was asked to proceed with development of an engineering model.

3.5.3.1   Program of Development Activities

This project encompasses the design, construction, and testing of an engineering model radar display recording/playback system at NAFEC. Testing and evaluation of the engineering model will establish the parameters and design criteria to incorporate into a technical data package.

3.5.3.2   Development Products

The product of the development efforts will be a technical data package. Evaluation reports of the breadboard and the engineering models, analyses, and other appropriate documentation will be included to support the preparation of production system specifications.

3.5.4   Interface Processor Development

This project provides for the development, test, and evaluation of an interface processor engineering model to replace the Peripheral Adapter Modules in the IBM 9020 en route computer system. The Peripheral Adapter Modules, which handle low and medium speed interfaces in the 9020 data processing system, are currently near capacity and lack flexibility for increased capacity to accommodate new types of communications lines, e.g., the Discrete Address Beacon System (DABS). DABS will greatly increase the number of communications lines coming into the 9020 system. Since it is likely that the present radar system will continue to be used for some period of time after DABS is implemented, these current interfaces could not be released to accommodate DABS.

The goal is to design an interface processor with sufficient capacity and flexibility to (1) satisfy existing en route system interface requirements and (2) enable the en route computer system to accommodate DABS and other planned system interface requirements such as NADIN, ARTS II, weather processing, ETABS, etc. The interface processor design will also be adaptable to an en route computer replacement system and provide the capability for performing some of the current 9020 system preprocessing tasks.

3.5.4.1   Program of Development Activities

The development activities for this project will be accomplished in two phases. In Phase one a study will be conducted to analyze the functional requirements, projected input/output loads, and performance requirements for an interface processor.

The Phase one study effort will provide an Engineering Requirements document to be used in Phase two for the procurement of an interface processor engineering model. The engineering model will undergo extensive testing at NAFEC to evaluate the suitability of the design for accommodating (1) existing en route system interface requirements, (2) planned system interface requirements such as with DABS and its data link, and (3) some of the current 9020 preprocessing tasks such as buffering, error and logic checking, etc.

3.5.4.2 Development Products

Development products include analyses, reports, and specifications in the form of a technical data package for implementation of the enhancement.

3.6 Subprogram 122-114, Performance Analysis and Evaluation

This subprogram provides for performance assessments of automation capabilities developed for the En Route system. It includes hardware and software measurement and analysis, simulation and modeling, and system and controller performance evaluation to determine the impact and benefits of new automation features. The development projects included under this subprogram are:

1. Hardware Measurement and Analysis
2. Simulation Model Development
3. System Performance Evaluation
4. Controller Performance Evaluation

3.6.1 Hardware Measurement and Analysis

The objectives of the Hardware Measurement and Analysis Project are to measure and evaluate En Route software and hardware development efforts and assess their computer resource requirements as a function of new automation enhancements and the ATC role. The automation enhancements will be measured and evaluated on the En Route System Support Facility (SSF) using hardware monitors and software data reduction and analysis tools. Improved methods and techniques for hardware and software measurements will also be developed. Measurements of selected releases of the En Route Operational System will be taken to establish references for evaluating the performance of system enhancements.

3.6.1.1 Program of Development Activities

Activities of the project include:

1. Conducting research on, and improving the techniques of hardware and software monitoring.

2. Measuring the releases of the En Route Operational System to establish baselines of performance.

3. Measuring the performance of hardware and software development efforts and their effect on the En Route Operational System.

4. Developing improved workloads to represent En Route Air Traffic Control Centers in the SSF.

5. Establishing and maintaining a data base of performance measurement information.

3.6.1.2 Development Products

The products from the activities of this project include performance measurement research reports, system performance analysis reports, recommendations for improving and developing performance analyses tools, and recommendations for improving the En Route Operational System.

3.6.2 Simulation Model Development

The goals of the Simulation Model Development project are to have Models available as the nucleus for predictive studies of the NAS En Route System and to have a capability developed to automate the characterization of workloads for model input. While Models will not be continuously updated to represent the latest releases of the operational system, they will be available and can be updated for specific uses which manifest themselves during en route development projects and to support studies for the IBM 9020 replacement.

3.6.2.1 Program of Development Activities

Activities of this project include the following:

1. Automating the characterization and generation of ARTCC workloads as inputs to Models.

2. Conducting design analyses with the model of the Electronic Tabular Display Subsystem (ETABS).

3.6.2.2 Development Products

The expected products resulting from this project include an automatic Model Load Generator and a model of the ETABS Common Equipment Group and Sector Equipment Group.

3.6.3 System Performance Evaluation

The goal of the System Performance Evaluation project is to assess the relative improvements in the performance of operational ATC Systems due to the addition of new software and hardware developments and enhancements. This system performance data will contribute to the information currently available for making implementation decisions for the ARTCCs.

Indicies and metrics will be defined, data reduction and analysis programs will be developed, and procedures will be established to collect and analyze data during comparative system operational testing at NAFEC. Specific metrics to be defined may include Indicies of Hazard, Orderliness, and Delay.

3.6.3.1 Program of Development Activities

Activities in this project include the following:

1. Defining system performance indicies and metrics.

2. Specifying and developing data reduction and analysis programs.

3. Developing test plans and air traffic scenarios.

4. Conducting tests.

5. Analyzing and evaluating test results.

6. Preparing reports and recommendations.

3.6.3.2 Development Products

The products from the activities of this project include the definition of appropriate system performance indicies and metrics, system performance data reduction and analysis programs, test plans, and test reports.

3.6.4 Controller Performance Evaluation

The goal of the Controller Performance Evaluation project is to assess the relative improvement in the performance of the Air Traffic Controller due to the addition of new software and hardware developments and enhancements. This controller performance data will contribute to the information currently available for making implementation decisions for the ARTCCs.

Indicies and metrics will be defined, data reduction and analysis programs will be developed and procedures will be established to

collect and analyze data during comparative svstem operational testing at NAFEC. Specific metrics to be defined may include Direct Workload, Indirect Workload, Controller Stress, and Controller Attention.

3.6.4.1 Program of Development Activities

Activities of this project include the following:

1. Defining controller performance indicies and metrics.

2. Specifying and developing data reduction and analysis programs.

3. Developing test plans and air traffic scenarios.

4. Conducting tests.

5. Analyzing and evaluating test results.

6. Performing test and evaluation of the Electronics Tabular Display Subsystem (ETABS).

3.6.4.3 Development Products

The products from the activities of this project include the definition of appropriate controller performance indicies and metrics, controller performance data reduction and analysis programs, test plans, and test reports.

3.7 Subprogram 122-115, Interface Developments

This subprogram provides for the development of hardware and software interfaces between the En Route Svstem and other systems being developed. The following interface development projects are included under this subprogram:

1. Discrete Address Beacon System (DABS) Processing in the En Route System

2. Automatic Traffic Advisory and Resolution Service (ATARS) Processing

3. ETABS Software Interface Development

4. Terminal Information Processing System Interface (TIPSI)

5. Discrete Address Beacon System/Direct Access Radar Channel (DABS/DARC) Interface

6. Center Weather Service Unit (CWSU) Interface

3.7.1 DABS Processing in the En Route System

The Discrete Address Beacon System (DABS) is expected to be operationally deployed as an upgrade to the present Air Traffic Control Radar Beacon System (ATCRBS) secondary surveillance radar system. Extensive testing will be conducted of three Engineering Model DABS sensors and related interface and test equipment in preparation for production procurement.

This project provides support for the DABS Engineering Model test and evaluation effort. These activities will result in test software to exercise and evaluate the DABS/NAS Stage A interface and in experimental En Route ATC software.

3.7.1.1 Program of Development Activities

A DABS Interface Verification (IV) program and an associated DR&A program will be developed and used during establishment of the surveillance and communications interfaces between DABS and the 9020 computer system.

Initial ATC software developments will focus on the following functions: (1) processing DABS and ATCRBS surveillance reports , (2) automatic tracking of all controlled aircraft, (3) processing all surveillance-related communications data to/from DABS sensors while maintaining the agreed upon communications protocol with the DABS Front End Processor (FEP) and recording all communications between the 9020 Computer System and the FEP, (4) displaying controlled DABS tracks on the plan view display together with the data displayed by the current En Route ATC System, (5) providing for additional DABS-related data in various messages exchanged between the 9020 system and the controller and between the 9020 system and connected ARTS-III facilities, and (6) providing for the addition of DABS-related data into the Systems Analysis (DR&A) functions.

The Air Traffic Control Simulation Facility (ATCSF) will be used to simulate the operation of multiple DABS and ATCRBS sensors providing surveillance and surveillance-related communications inputs to the 9020 system. Design verification and DABS/ATC system tests will be conducted to determine the adequacy of the ATC software design. A subsequent software development activity will incorporate the results of simulation testing as well as the Operating Services' requirements for field deployable ATC software. Extensive technical and operationally oriented tests and evaluation of this software will lead to a Technical Data Package for en route ATC software.

3.7.1.2 Development Products

1. DABS IV program and related offline DR&A software.

2. Experimental En Route ATC Program and documentation.

3. Operational support software and documentation.

4. Design Verification and DABS/ATC system Test Reports

5. A Technical Data Package defining the En Route ATC Software System for the DABS/ATCRBS surveillance environment.

3.7.2 Automatic Traffic Advisory and Resolution Service (ATARS) Processing

The Automatic Traffic Advisory and Resolution Service is a fully automatic ground-based collision avoidance capability being developed to improve safety of flight and reduce the number of mid-air collisions between aircraft. While ATARS is not an element of the En Route Control program, as presently envisioned it will be interfaced to the En Route automation system via the DABS communication link to notify controllers of ATARS advisories. ATARS will utilize the two-way ground/air data link provided by DABS for automatic delivery of ATARS-issued traffic advisories and conflict resolution advisories.

Several technical and operational issues arise when field implementation of ATARS is considered. Among these are:

1. The content and timing of messages sent by ATARS to en route air traffic controllers warning them of an impending conflict involving an aircraft under their control.

2. An effective and efficient means of displaying ATARS-generated messages to the controller.

3. The optimum roles of the controller and the ATC automation system in ATARS message formulation and delivery.

4. A means of preventing/resolving conflicting advisories issued to the controller by ATARS and the ATC Conflict Alert/Resolution Advisory functions.

5. An assessment of the impact of ATARS upon controller workload and upon storage and computational resources of the 9020 automation system.

3.7.2.1 Program of Development Activities

The DABS Engineering Models being delivered will contain an ATARS algorithm which will undergo testing to insure compliance with development specifications. Concurrent with Engineering Model development, efforts will be expended to develop an improved ATARS function. More sophisticated resolution concepts will be formulated, developed, and evaluated in a longer range activity.

It is expected that, for ATARS, receiving and displaying resolution advisories to the appropriate ARTCC controller will be required.

Coordination will be effected with the ATARS program office to develop a suitable interface between ATC and ATARS. Studies will be conducted where feasible to investigate display techniques and the content and timing of messages crossing the interface.

When the ATC/ATARS interface is sufficiently defined, logic will be designed and coded into the En Route software to display ATARS messages received from the ATCSF and the DABS Engineering Models. When a tested and validated Conflict Resolution Advisory function is available, it too will be incorporated into the ATC software in order to assess the compatibility with ATARS.

3.7.2.2 Development Products

1. Reports concerning various interface and display concepts.

2. Experimental En Route ATC programs and documentation for operations with DABS/ATARS.

3. Design Verification and Operational Test Reports.

4   A Technical Data Package for field implementation of En Route ATC software to interface with ATARS.

3.7.3 ETABS Software Interface Development

An Electronic Tabular Display Subsystem (ETABS) engineering model will be developed under Subprogram 122-113 (See Section 3.5.1). Extensive system testing will be conducted at the NAFEC SSF with the ETABS engineering model to evaluate and refine the design. To accomplish this testing, it will be necessary for ETABS to interface and operate with the NAS en route software/hardware system (9020). The ETABS Software Interface Development project provides for the development and testing of 9020 software to interface the ETABS equipment with the 9020 system. Results will be used to specify en route software changes which will be required for national implementation of ETABS.

3.7.3.1 Program of Development Activities

ETABS Interface Requirements will first be translated into specific functional requirements of the en route computer program. Computer program functional specifications necessary for the en route computer program when interfaced with ETABS will then be developed. These specifications will identify all functional changes and additions to the existing en route computer program in order to successfully interface with the ETABS hardware/software system. Appropriate modifications to the en route software will then be designed, developed, and tested.

3.7.3.2 Development Products

Development products will include functional specifications for the
ETABS interface, program design specifications for the changes and
additions to the en route program, and data reduction and analysis
programs to assist in test and evaluation activities. Test plans and
analysis reports of test results will also be prepared. Following
testing, change pages to the CCC Computer Program Functional
Specifications will be produced. These change pages will be included
in an ETABS Technical Data Package to support field implementation of
ETABS.

3.7.4 Terminal Information Processing System Interface (TIPSI)

The Terminal Information Processing System (TIPS) is intended to
accept, process, distribute, and display flight and other non-radar
data for an entire terminal area including the Terminal Radar Control
Facility and its related towers. When developed, TIPS will interface
with the host Air Route Traffic Control Center (ARTCC) and will place
certain demands on the ARTCC's automation facility.

TIPS project plans call for the development of two prototype TIPS
systems followed by an extensive test and evaluation. The purpose of
this TIPS Interface (TIPSI) Project is to define, develop, test,
document, and support changes to the en route ATC computer program
which are required in order to interface with TIPS.

Input/Output and processing requirements in the en route CCC system
for TIPS include:

(a) Processing new and revised CCC/TIPS and CCC/ARTS messages.

(b) Processing FDEP-type messages to/from TIPS via Interfacility
Lines.

(c) Providing for the transfer of flight plans to TIPS as early
as two hours before proposed departure time.

(d) Processing amendements received from TIPS concerning flight
plans which have not been activated in the CCC.

(e) Providing for three interface modes: standard CCC/ARTS III,
CCC/TIPS and ARTS, and CCC/TIPS.

3.7.4.1 Program of Development Activities

An analyses of the various CCC/TIPS interface and CCC processing
modes will be conducted and specific functional requirements of the
en route computer program will be defined. Program design
specifications for the changes and additions to the en route software
will then be prepared. En Route computer program modifications will

be made in advance of the expected TIPS prototype delivery to ensure availability of the software and related documentation. Quality Assurance Testing and Design Evaluation will ensure that the modified ATC program meets specifications and is sufficient for TIPS test and evaluation.

3.7.4.2 Development Products

1. Analyses of the different CCC processing and CCC/TIPS interface modes.

2. Experimental En Route ATC program and documentation.

3. Quality Assurance and Design Evaluation test reports.

4. Change pages to the CCC Computer Program Functional Specifications for inclusion in the TIPS Technical Data Package.

3.7.5 DABS/DARC Interface

It is expected that Discrete Address Beacon System (DABS) sensors will be developed as part of the National Airspace System during the early 1980's. These sensors will provide for improved secondary surveillance radar and a high capacity digital data link. (See Sections 3.4.5 and 3.7.1).

A Discrete Access Radar Channel (DARC) is being implemented at NAS Stage A ARTCC's. Prior to the implementation of DARC, only broadband surveillance information could be displayed to controllers when the CCC was unavailable. DARC has been designed to accept inputs from existing en route surveillance sites via the common digitizers and provide a digital backup capability for controllers when the en route Central Computer Complex (CCC) is unavailable. DARC will provide digital aircraft target report data, alphanumeric data blocks, weather data, and map data on the radar controllers plan view displays.

This project provides for the development, test and evaluation of software/hardware modifications to DARC to accommodate DABS sensor surveillance data.

3.7.5.1 Program of Development Activities

A design analysis study will be conducted to identify specific changes that will be required in DARC software to interface with DABS. The study will also identify whether any hardware changes are required for a DABS/DARC inteface. Various software/hardware approaches to accommodate the identified changes will then be analyzed and computer storage and processing estimates will be developed. An approach will be selected that ensures optimum use of memory space and computer time. Computer program functional specifications and an Interface Control Document will be prepared as a result of these efforts.

A test configuration of DARC equipment will be procured and installed at NAFEC to interface with the SSF and the DABS Engineering Model. A modified DARC computer program to accommodate the processing of DABS messages will also be developed. Testing and evaluation of the DABS/DARC interface will then be conducted to establish design criteria that will be incorporated into a technical data package.

Future development activities for DARC may include interfacing ETABS and other DARC enhancements such as the addition of tracking, mosaicking and data link features.

3.7.5.2 Development Products

Development products include analysis reports, test plans and evaluation reports and functional specifications for DARC software/hardware modifications in the form of a technical data package.

3.7.6 Center Weather Service Unit (CWSU) Interface

Center Weather Service Units (CWSU's) in the ARTCC's will be the major focal points for the real-time collection, monitoring, interpretation, and dissemination of hazardous weather information. System studies will be conducted under Program 15 (Weather) including alternative design approaches for the processing, communication, and display of alphanumeric weather and weather radar/line graphic data within the ARTCC's at the individual sector positions of operation.

The purpose of this CWSU Interface project is to support Program 15 in accomplishing changes to the en route system which will be required in order to interface the CWUS's with the ARTCC sector positions of operation. A program of development activities to be conducted under Program 12 and development products will be defined and included in the En Route Control Program Plan when specific requirements are identified.

3.7.6.1 Program of Development Activities

RESERVED

3.7.6.2 Development Products

RESERVED

3.8 Subprogram 124-111 En Route Sustaining Engineering

This subprogram provides for developmental support in the analyses and resolution of field system problems and design deficiencies.

In response to requests from the operating services of the FAA, technical efforts are required to diagnose and correct in-service

problems experienced with operational equipment in the ARTCC's. This includes field adjustment and correction activities which relate to special reliability problems, improvement of maintenance or performance monitoring provisions and procedures, and investigation and solution of site unique problems. These problems require R&D efforts which are beyond the capability of the field sites and operating services. Also included is engineering support required in the implementation of field retrofits of new components or improved subsystems.

Specific projects are not described in this program plan, since the intent is to provide quick, short term response to field problems. This activity is conducted on a level-of-effort basis, and E&D resource requirements are estimated in Appendix C by extrapolation of past experience.

4. RELATIONSHIP WITH OTHER ENGINEERING AND DEVELOPMENT PROGRAMS

4.1 Introduction

Program 12, En Route Control, is closely related to many of the other
20 E&D programs because of design and interface relationships. The
E&D efforts in other programs often require Program 12 to effect
changes to en route hardware, software, and ATC procedures to enable
satisfactory system integration of the intended operational
capability. For example, the introduction of a Discrete Address
Beacon System (DABS) as a part of the beacon subsystem development
will require design changes in the en route program. Changes needed
in the en route program to provide compatibility with beacon (DABS)
improvements cannot be accomplished in a timely manner without
parallel efforts of the two development programs. Because of this
type of interaction, close coordination is required between Program
12 and the other E&D programs.

4.2 Program Relationships

The following subsections identify and describe activities in other
E&D programs which have interface or design implications with respect
to the En Route Control Program:

1. Program 01 - Air Traffic Control System

This program establishes the goals, overall development
objectives, and general approach of the total E&D effort. It is
concerned with formulating concepts, broad system descriptions, and
design guidelines for the future ATC system in order to provide
direction for the various development activities in all other E&D
programs.

An example of a study conducted in this program that relates
directly to the en route program is described below.

The Office of Systems Engineering Management (OSEM) is
exploring, both analytically and experimentally, certain concepts for
more fully automating en route ATC clearances and advisory services
to aircraft. The design goals that have been identified to establish
design criteria for this effort, entitled Automated En Route ATC
(AERA), are (1) accommodating users flight preferences, (2) reducing
the opportunities for system errors, (3) improving ATC system
performance monitoring and supervision, (4) increasing pilot
participation in the clearance planning process, and (5) increasing
controller performance. A basic experimental AERA system has been
created as a simulation. This experimental system provides (with
varying degrees of capability) flight tracking, clearance planning,
human interaction, clearance delivery and progress monitoring
functions.

The objective of the AERA effort is to demonstrate the feasibility of automating most of the routine en route air traffic controller functions. OSEM activity will continue the development and experimentation of AERA to automate the en route air traffic control function as it is currently defined while allowing the flexibility required to accommodate future system concepts. Testing will then be conducted during which time algorithms will be debugged and refined and human factors questions will be addressed. A definitive answer to the question of technical feasibility and a preliminary answer to the question of economic feasibility will be provided upon completion of the test period. An affirmative answer to the question of technical feasibility will be dependent upon the successful development and demonstration of the required algorithms. The preliminary answer to the question of economic feasibility will rely on (1) estimated system development and implementation costs, derived from system design documentation and (2) the degree to which the automated system can be used to provide increases in performance, derived from experimental system testing.

A plan outlining major development objectives and activities as well as the transitioning from OSEM to SRDS for applied development of AERA will be prepared jointly by OSEM and SRDS.

2. Program 02 - Radar

This program includes development efforts that are directed toward improving the performance of primary radar sensors and achieving compatibility between primary radar sensors and the Discrete Address Beacon System (DABS). Radar sensor developments relating to the improved detection of aircraft and hazardous weather must be closely coordinated with en route program development efforts. A Moving Target Detector (MTD) capability being developed under Program 02, to improve the detection and tracking of aircraft in the presence of ground and preciptation clutter, relates directly to the en route program. The MTD processing system measures the range rate of primary radar targets with a high degree of accruacy. Therefore, in addition to improving the detection and tracking of aircraft in ground and preciptation clutter, it is also expected that the application of range rate processing to the en route tracking function will significantly improve the trackers responsiveness to aircraft turn maneuvers. Such improved responsiveness could lead to improved performance of en route ATC automation functions such as Conflict Alert and En Route Minimum Safe Altitude Warning. Development activities pertaining to the application of range rate processing to the en route tracking function are included under the En Route Control Program. (See Section 3.3.1, Surveillance System Improvements.)

3. Program 03 - Beacon

This program includes activites directed toward improving the performance of the existing Air Traffic Control Radar Beacon System (ATCRBS), the design and development of the Discrete Address Beacon System (DABS), and the development of an Automated Traffic Advisory and Resolution Service (ATARS) capability at the DABS surveillance sites. DABS will provide a new surveillance sensor compatible with ATCRBS, with greater precision and more capacity, and having discrete address and a two-way ground/air data link capability. ATARS is a fully automatic ground-based collision avoidance capability being developed to improve the safety of flight. ATARS will utilize the two-way ground/air data link provided by DABS for automatic delivery of ATARS-issued traffic advisories and conflict resolution advisories. The DABS and ATARS developments have both interface and design implications with the en route system. (See Sections 3.5.4, Interface Processor Development; 3.7.1, DABS Processing in the En Route System; 3.7.2 ATARS Processing; and 3.7.5 DABS/DARC Interface).

4. Program 05 - Airborne Separation Assurance

This program includes the development of an airborne collision avoidance system. This system, referred to as the Beacon Collision Avoidance System (BCAS), offers separation assurance and data link services among equipped aircraft. It incorporates ranging on the basis of secondary surveillance radar replies that are initiated by ground interrogation, airborne interrogation, or both.

The primary objective of the BCAS program is to enhance the safety of air travel by reducing the potential for mid-air collisions. Supplemental protection will be afforded to aircraft operating inside coverages of the ground based ATC system, where ATARS is not in operation; and primary protection to aircraft outside ATC system coverage. To achieve compatiblity between the ground based ATC system and the BCAS system, liasion is required between Programs 12 and 04. If efforts are required to evaluate interaction between BCAS and the en route conflict alert and resolution advisory functions, such efforts will be conducted as part of the Program 12 development activity.

5. Program 06 - Communications

This program includes activities to (1) develop and assess applications for using the DABS data link for aviation-related messages between airborne and ground systems and (2) provide improvements to the voice and digital communications switching and control systems associated with air traffic control facilities.

The DABS data link application development efforts conducted under Program 06 require continuing coordination with Program 12.

Program 06 activities will define the necessary ground system interfaces and data information sources, the means of formatting the information and the air-ground link, and the required pilot and controller interaction. Program 12 development activities will provide the test software/hardware modifications that are required to deliver and receive ATC data link messages for those functions that are performed in the en route computer and provide man-machine interface enhancements to maximize controller efficiency of data link usage for future applications. (See Section 3.4.5, Control Message Automation).

The national ground-to-ground digital message switching network being developed under Program 06 requires continuing liaison with Program 12 development activities to ensure compatibility e.g., Interface Processor Development (See Section 3.5.4). This network, the National Airspace Data Interchange Network (NADIN), will initially replace some of the existing inefficient, independent, low-speed networks and switches. It will integrate the present Aeronautical Fixed Telecommunications Network (AFTN), Service B system, selected Service A weather data, and NAS NET into a single Aeronautical user manager network. NADIN will interface with the Weather Message Switching Center to provide selected Service A weather products to ARTCCs, interface with the enroute computer system, the Flight Service Information System, and the central flow control Air Traffic Control System Command Center. Subsequent additions to NADIN, under the NADIN enhancement program, may include further integration of data communications used in support of air traffic control e.g., digital data transfers between ARTCC's and between ARTCCs and the terminal areas could be conducted through NADIN.

6. Program 13 - Flight Service Stations

This program includes efforts to modernize the Flight Service Station (FSS) environments and equipment, to apply automation (Flight Service Data Processing Systems) to assist in the performance of FSS functions and to achieve a reconfiguration of the FSS network. The en route system presently has an interface with selected FSS's via the Service B teletype network. With the implementation of NADIN, the en route system will interface with FSS's via a NADIN concentrator. Program 12 develoment activities such as Interface Processor Development (Section 3.5.4) require coordination with Program 13 regarding en route system design requirements resulting from new FSS automation capabilities and interfaces.

7. Program 14 - Terminal Tower Control

This program includes efforts to develop new automation techniques that will aid controllers in predicting and resolving potential aircraft conflicts and in the sequencing, metering and

spacing of terminal traffic. It also includes efforts to improve the capability for entering, displaying and distributing flight plan and other non-radar data in the terminal environment. In addition, Program 14 includes efforts to develop the concepts, functional requirments and hardware/software to interface with systems being developed under other programs, e.g., the discrete address beacon and data link systems.

Since Programs 12 and 14 both include development efforts for new automation techniques that will aid controllers; improving the capability for entering, distributing and displaying flight plan data; and interfacing with systems being developed under other programs; there are similarities in many of the capabilities to be developed for the en route and terminal systems. The relationship between Programs 12 and 14 for development activities of this nature requires liaison for coordination of concepts, requirements and proposed approaches.

Efforts in Program 14 that have direct interface and design implications with the en route system are Metering and Spacing and the Terminal Information Processing System (TIPS). The Metering and spacing function being developed in Program 14 is intended to provide automation techniques to aid controllers in the sequencing, metering and spacing of terminal traffic arriving/departing medium to high activity airports.

The En Route Metering design being developed in Program 12 (See Section 3.4.4) will accommodate a digital interface with the terminal Metering and Spacing function to provide for an automatic exchange of data between the en route centers and terminals. The TIPS being developed in Program 14 is intended to eliminate the need for the present paper flight progress strips and the Flight Data Entry and Printout (FDEP) Subsystem which interfaces the terminals with host ARTCCs. This will be accomplished by the introduction of electronic displays and by automatic data processing and electronic routing. TIPS will require software modifications within the enroute computer system to accommodate expanded flight data requirements from the ARTCCs to the terminals. Development activities pertaining to changes to the en route ATC computer programs are included in Program 12. (See Section 3.7.4, Terminal Information Processing System Interface). Development of the En Route Metering function and the TIPS interface require close coordination with Program 14.

8. Program 15 - Weather

This program includes efforts to improve the detection, prediction, collection, interpretation and dissemination of aviation weather tailored to the requirements of pilots and the air traffic control system. The major focal points for the real-time collection, monitoring, interpretation and dissemination of hazardous weather information will be the Center Weather Service Units (CWSU's). The

CWSU data bases will contain both alphanumeric data e.g., weather observations, forecasts and Pilot Weather Reports (PIREPS), and weather radar/line graphic data. National Weather Service meteorologists at the CWSU's will provide real-time weather support services for the ARTCC areas of responsibility including the collection and dissemination of PIREPS and the filtering and annotating of weather radar data. System studies will be conducted under Program 15 including alternative design approaches for the processing, communication, and display of the alphanumeric weather and aeronautical data and the weather radar/line graphic data within the ARTCC's. Program 15 efforts of this nature have both interface and design implications with the en route system. Alphanumeric weather and aeronautical data and weather radar/line graphic data will be required at the individual sector positions of operation within the ARTCC's in addition to being available at the CWSU's. Program 15 requirement and system design activities pertaining to the processing, communication and display of weather data within the ARTCC's require close coordination with the ETABS (Section 3.5.1) Interface Processor Development (Section 3.5.4) and Center Weather Service Unit (CWSU) Interface (Section 3.7.6) projects in Program 12 to ensure that all requirements are identified and an efficient, integrated system design.

9. Program 16 - Technology

This program includes analyses, feasibility studies, experimentation, and design development activites of new techniques and technology to determine their applicability in meeting future system requirements. The results of these activities are used as a basis for follow-on development in specific program areas where such applications are appropriate.

Current Program 16 efforts that have a direct relationship with Program 12 are:

a. Efforts to develop a comprehensive plan for meeting future ATC computing requirements with a data processing system that can be implemented, maintained, and operated in a cost-effective manner and that can evolve in an orderly manner as operational and environmental requirements change.

b. Efforts to investigate improved man-machine interface techniques and to define the proper role of humans in highly automted ATC systems and cockpits.

10. Program Element 123 - Advanced En Route Development (ATC Computer Replacement)

This program element includes long-range development activities for the future ATC Automation System. It includes activities required to establish hardware and software designs for

replacement of the existing En Route Data Processing System. It involves analysis of the existing system and of planned developments to that system as described for Program Element 122. It also involves replacing an on-line, real-time, operational system at the ARTCC's with minimal impact on ATC operations. Thus, close coordination must be insured between Program Elements 122 and 123 of the En Route Control Program in the areas of new functional developments and transition.

5. IMPLEMENTATION CONSIDERATIONS AND TRANSITION OF MANAGEMENT RESPONSIBILITIES

5.1 General

The previous sections of the program plan have described the development activities to achieve improvements to the En Route ATC System. A complementary effort to these development activities will be the planning and preparation for field implementation of the development products. Since implementation decisions and deployment activities are the responsibility of the operating services, the establishment of implementation plans are outside the scope of the en route development program. It is recognized, however, that development and implementation planning efforts are interdependent and that close coordination is required between these activities. This section presents considerations regarding the division of organzational responsibilities in transitioning from development to implementation.

5.2 Implementation Planning Factors

5.2.1 Development Considerations

The Systems Research and Development Service (SRDS) is responsible for the en route development activities described in this plan. This includes documentation of development products to provide Technical Data Packages for use by the operating services for production procurements and field deployment. It also includes support to the operating services in phasing developmental software into operational computer program versions for field test and final integration. The development plan does not include the routine changes and design efforts by the operating services to meet immediate requirements and to maintain satisfactory performance of the en route system. Thus, it is necessary for SRDS and the operating services to coordinate their efforts to ensure compatibility between plans for the operational system and the development program.

The time phasing of en route development activities is presented in Appendix B. The development projects shown on the schedule also reflect the efforts needed to interface the en route system with products developed under other E&D programs.

5.2.2 Field Implementation Considerations

The concept for phasing the developmental products into operational use at the ARTCCs is by incremental introduction of products for implementation as they are developed. Factors that will affect the order of development products and decisions for implementation are summarized as follows:

1 The priority the operating services attach to a specific new capability.

2. The state of development of the desired capability.

3 The inter-dependence of the capability with other capabilities and their state of development.

4. The ability of the en route system computer resources to accommodate the change.

5. The availability of funds.

Close coordination is required between SRDS and the operating services to determine which development products are candidates for implementation and the timing for their introduction into the operating system.

5.3 Transition of Management Responsibilities

5.3.1 Transition of responsibility from SRDS to the operating services may occur at different points during the development process. The time of transition for any specific product will be dependent upon the degree of complexity of the testing and implementing activities, availability of resources, and coordination between SRDS and the operating services.

1. Transitioning normally occurs after SRDS validation at the SSF. SRDS will be responsibile for completing the development and testing activities at the SSF. The operating services will be responsibile for completion of the modifications to computer programs, acquisition of production hardware, and all test/implementation activities at the field sites. Formal transition of primary management responsibility for a given implementation package from SRDS to the appropriate operating service, Air Traffic Service (ATS) or Airway Facilities Service (AFS), will be effected with transmittal of:

a. Procurement documentation to AFS in the case of production hardware.

b. Program Design Specifications, Computer Program Functional Specifications, and Subsystem Design Data to ATS (or to AFS for non-operational equipment related programs) in the case of software.

2. In some cases SRDS will provide support to the operating services in transitioning of software products. This support may include (1) conversions of development software to operate compatibly with current field versions of operational computer programs, (2)

support and assistance in field testing activities, (3) assistance in analyses of field test data and (4) assistance in establishing appropriate computer program adaptation parameters. Following the transition of the SRDS responsibilities, the primary responsibility for configuration management shifts to the operating services.

5.3.2 Maintenance of the software will be the responsibility of the operating services after the transition of primary management responsibilities from SRDS to AFS and ATS has occurred; AFS is responsibile for maintenance of installed production hardware.

5.4 Training

Training requirments to support the implementation of development products must be recognized by the operating services early to enable personnel training on a schedule that is compatible with implementation plans. As required, SRDS will provide information to the operating services concerning the degree of difficulty and complexity of the various development projects for assisting their establishment of training requirements and programs. It will also provide system documentation as it becomes available for use in developing training course material. Following a decision to proceed with implementaton, actions to initiate appropriate training programs and acquire any necessary training equipment should be undertaken by the Operating Services and the Office of Personnel and Training as part of the implementation program.

APPENDIX A

PROGRAM BASE

1. MODEL A3d2

The current baseline en route automated system is represented by the Model A3d2 software system. This provides the starting point for this development plan. The flight data and radar data processing capabilities of Model A3d2 are operational at all ARTCCs within the conterminous United States.

2. SOFTWARE FUNCTIONAL CAPABILITIES

Model A3d2 provides the following functional capabilities:

   a. On-line entry of proposed flight plans. Flight plans are transmitted to the ARTCC from both local and remote sources such as Flight Service Stations (FSS), military base operations offices, and airline offices. Bulk storage and automatic retrieval of pre-filed flight plans are also provided.

   b. Automatic data exchange between ATC facilities. Data include active or proposed flight plans, tracking and air traffic control data. Computer-to-computer exchanges occur between adjacent ARTCCs and with ARTS III equipped Terminal Radar Control Facilities (TRACONs). Flight plan data are also provided to TRACONs and on-line towers via the Flight Data Entry Position (FDEP) equipments.

   c. Automatic error and legality checking. All inputs to the data base at the ARTCC are automatically checked for both acceptable and unacceptable inputs. Response is made to the source for correction or retransmission, where possible.

   d. Automatic flight plan preparation/revision. This function is performed at the ARTCC prior to the issuance of the clearance, based on pre-stored procedural agreements.

   e. Initiation of automatic processing on departing flights. This is accomplished via FDEP from on-line towers/TRACONs. Subsequent tracking and flight plan processing is initiated at the ARTCC without further manual intervention.

   f. Automatic flight plan updating, data forwarding, and display. Time-of-arrival estimates are automatically calculated for key navigation and control points. Updates are generated automatically for tracked aircraft or as a result of manually entered flight plan revisions. Automatic flight plan forwarding from the ARTCC to adjacent facilities and display generation for internal control positions is based on stored lead-time parameters and the latest time-of-arrival estimates.

g. <u>Automatic tracking.</u> Both beacon-equipped and non-beacon aircraft are tracked by the system. Tracks are automatically initiated on aircraft equipped with discrete beacon capability.

h. <u>Radar inputs processing.</u> This capability includes mosaicking of radar coverage.

i. <u>Automatic track and track control updating, data forwarding and display.</u> Controller-selected alphanumeric and velocity vector data is automatically associated with the present track position for display. Updates are automatically generated, based on both flight plan and surveillance data returns. Handoff data are automatically forwarded to the next control position, either within the facility or at the next facility at transfer of control time. Transfer of control can be automatically or manually initiated, but is always manually assumed by the receiving controller.

j. <u>Conflict Alert.</u> The conflict alert function, using information available in the 9020 computer from the automatic tracking function and the flight plan data base, provides the radar controller with an alert on his plan view display of the impending situation of aircraft separation being less than minimum. The alert is generated a short time before the separation minimum might actually be violated.

3. HARDWARE SUBSYSTEMS

The hardware subsystems comprising the A3d2 baseline system are identified below, with a brief description of the purpose of each subsystem:

a. <u>Radar Data Acquisition and Transfer (RDAT) Subsystem:</u>

The RDAT Subsystem provides separate outputs to fulfill the requirements of both the ATC en route and Air Defense systems. This subsystem consists of long range search radars, beacon radars, common digitizers and data transmission and receiving equipments.

b. <u>Central Computer Complex (CCC) Subsystem:</u> The CCC is the central point for the collection, processing, and distribution of flight and control data. It accepts and error-checks inputs; processes the inputs using stored programs and data base; formats and distributes outputs for printing or display locally or at remote locations.

c. <u>Data Entry and Display Subsystem:</u> The Data Entry and Display Subsystem converts messages (radar, flight plan, weather and other data) received from the CCC Into data presentations to appropriate personnel in the ARTCC. It also provides an interface through which these personnel can transmit messages to the CCC and select data for display.

d. Communications Subsystem: A digital communications capability is provided for transfer of flight information and track data between computers of adjacent facilities. Teletypewriter service using FDEP equipment is provided for the transfer of flight data between ARTCC's and FSS's, airline offices, and military operations, control towers and terinal approach control facilties.

e. System Maintenance and Monitoring (SMM) Subsystem: The overall system monitoring of the en route equipment is provided by a SMM console (SMMC) located at a central location in the ARTCC operating area. At this location, personnel are alerted to equipment failure in the system and are provided with printed error and quality control analyses for each subsystem. System status and configuration is monitored at the SMMC. Interphone and external telephone communication capability is part of the SMMC Subsystem functional capability.

f. Direct Access Radar Channel (DARC)

The DARC accepts inputs from existing en route surveillance sites via the common digitizers and provides a digital backup capability when the CCC is unavailable. DARC provides digital aircraft target report data, alphanumeric data blocks, weather data, and map data on the radar controllers plan view displays.

APPENDIX B

TECHNICAL PROGRAM SCHEDULE

The following schedules depict the time required to complete the development cycle for specific functional capabilities and products. Because the nature of activities for some subprograms is continuous, schedules for them are not shown. Those which fall in this category are as follows:

    Development Support (122-109)
    Program Planning and System Engineering (122-110)
    Performance Analysis and Evaluation (122-114)
    En Route Sustaining Engineering (124-111)

Plan Ref.	SUBPROGRAM ACTIVITIES	FY 79 / CY 79	80	81	82	83
3.3.	NAS STAGE A IMPROVEMENTS (122-111)					
3.3.1	SURVEILLANCE SYSTEM IMPROVEMENTS	--1▽--	--1▽--	--2▽--	·····△	
3.4	AUTOMATION FUNCTIONAL DEVELOPMENT (122-112)					
3.4.1	CONFLICT ALERT ENHANCEMENTS	------	·····△			
3.4.2	CONFLICT RESOLUTION ADVISORY	------	--1▽--	--2▽--2▽--	·····△	
3.4.4	EN ROUTE MININUM SAFE ALTITUDE WARNING	··△ ▶	--1▽--			
3.4.5	EN ROUTE METERING	------	--2▽-- Phase II	--2▽--2▽--	△ Phase I --2▽--	--2▽--
3.4.6	CONTROL MESSAGE AUTOMATION	--2▽--	···	--2▽--2▽--	·····△	
3.5	AUTOMATION EQUIPMENT DEVELOPMENT (122-113)					
3.5.1	ELECTRONIC TABULAR DISPLAY SUBSYSTEM	3▽	--4▽·····	·····△	--1▽--	--2▽--

LEGEND: -----   Concept, Design and Development
               .....   Test and Evaluation

▽ Interim E&D Products
   1 - Reports/Documentation
   2 - Interim Specs.
   3 - Engineering Requirement
   4 - Engineering Model

△ E&D End-Item Products

▶ Implementation Initiation

Plan Ref.	SUBPROGRAM ACTIVITIES	FY 79 / CY 79	80	80	81	81	82	82	83	83
3.5.2	RADAR POSITION ENHANCEMENTS	1 ▽		▽		2 ▽		3 ▽		4 ◁
3.5.3	RADAR DISPLAY RECORDING/ PLAYBACK SYSTEM	3 ▽	4 ▽	△						
3.5.4	INTERFACE PROCESSOR DEVELOPMENT		▽	▽		▽		3 ▽		
3.7	INTERFACE DEVELOPMENTS (122-115)					3 ▽			4 ▽	
3.7.1	DABS PROCESSING IN THE EN ROUTE SYSTEM		2 ▽	1 ▽ Build I	2 ▽	Build II 1 ▽		△ Build III		
3.7.2	AUTOMATIC TRAFFIC ADVISORY AND RESOLUTION SERVICE PROCESSING			▽	2 ▽		▽	△		
3.7.3	ETABS SOFTWARE INTER- FACE DEVELOPMENT		2 ▽		△					
3.7.4	TERMINAL INFORMATION PROCESSING SYSTEM INTERFACE (TIPSI)		2 ▽		△					
3.7.5	DABS/DARC INTERFACE				1 ▽	2 ▽			△	

LEGEND:

----- Concept Design and Development

..... Test and Evaluation

▽ E&D Interim Products
1 - Reports/Documentation
2 - Interim Specs.
3 - Engineering Requirement
4 - Engineering Model

△ E&D End-Item Products

APPENDIX C

RESOURCE ESTIMATES

This appendix identifies resource estimates to support the en route development projects described in Section 3 of this plan in accordance with the schedules shown in Appendix B.

For FY-79, the funding is consistent with the approved FY-79 fiscal program. For FY-80, the funding is consistent with the FY-80 budget submission. The funding totals shown in the appendix for FY-81 through FY-83 conform to the yearly estimates in the Engineering and Development Five Year Plan.   For FY-80 and subsequent years, the plan reflects a level of expenditure which does not account for possible budget limitations and changes in priorities. For these reasons, the funding levels for the program will not necessarily correlate with the actual FAA Engineering and Development budget for any given fiscal period.

The funding totals shown in Table C-I are broken down by resource estimates for SRDS in-house personnel; NAFEC personnel, Transportation Systems Center (TSC) personnel, facilities and services; and contractor support for system engineering and development of hardware and software. The funding totals shown in Table C-II are broken down by total resource estimates for each subprogram.

TABLE C-I

SUMMARY OF FUNDING ESTIMATES
FOR EN ROUTE CONTROL PROGRAM

($ in Thousands)

PROGRAM 12 RESOURCE ESTIMATES	FY-79	FY-80	FY-81	FY-82	FY-83
SRDS In-House Personnel	577	565	595	350	350
NAFEC Personnel, Facilities and Services	4007	4021	3800	2100	2250
TSC Personnel, Facilities and Services	70	305	160	400	350
System Engineering and Development Contractor Support	5120	3590	2675	4150	3650
TOTALS	9774	8481	7230	6500	6600

TABLE C-II

ESTIMATED FUNDING
FOR EN ROUTE CONTROL SUBPROGRAMS*

($ in Thousands)

Plan Ref.	SUBPROGRAM	Subprogram (Number)	FY-79	FY-80	FY-81	FY-82	FY-83
3.1	Development Support	(122-109)	1263	914	880	700	700
3.2	Program Planning and System Engineering	(122-110)	1005	1150	1075	1050	1100
3.3	NAS Stage A Improvements	(122-111)	174	260	220	–	–
3.4	Automation Functional Development	(122-112)	1155	1489	1520	750	750
3.5	Automation Equipment Development	(122-113)	2954	1781	1305	2350	2200
3.6	Performance Analysis and Evaluation	(122-114)	968	685	800	550	650
3.7	Interface Developments	(122-115)	1754	1472	1160	1100	1200
3.8	En Route Sustaining Engineering	(124-111)	501	730	270	–	–
	TOTALS		9774	8481	7230	6500	6600

* These estimates include funding for both in-house and contractor support.

C-3